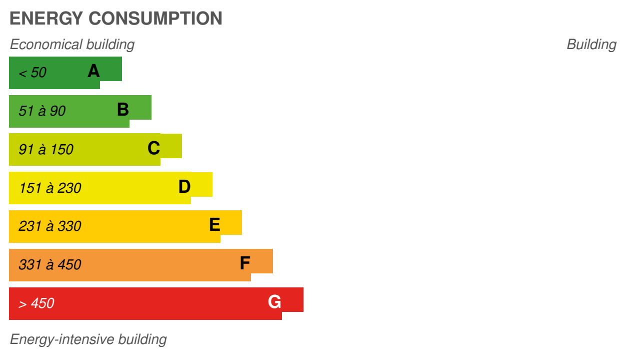
Modular Office Renovation Prototype

by Aurelie Griveaux / 2021-03-26 16:27:51 / International / 3759 / EN

Primary energy need :

51 kWhpe/m^2.year

(Calculation method : Other)



Building Type : Other building
Construction Year : 2019
Delivery year : 2019
Address 1 - street : Van Den Broekweg 4, 2628 CR DELFT, Netherlands
Climate zone : [Cfb] Marine Mild Winter, warm summer, no dry season.

Net Floor Area : 75 m^2 Other

Proposed by :

mor studio

General informations

The MOR project was realised in 2019, for the Solar Decathlon Europe Competition.

A group of over 46 TU Delft students came together, from 8 different disciplines and 20 different nationalities, all sharing a passion for sustainability.

MOR's innovative and feasible solutions were awarded 8 out of the 10 contest categories, setting a world record and rewarding the team with the 2nd overall prize.

MOR stands for Modular Office Renovation. It translates the mission of the team: to transform under-performing office buildings into net-positive, flexible buildings. This goal was guided by the principles of modularity and circularity.

MOR implemented and validated its modular design & engineering solutions into a full scale prototype, showcasing how future dwellings could look like.

The prototype resembles a cutout of the iconic Europoint Towers, located in the M4H district in Rotterdam.

The towers represents a typical office building, built in the 1970s, in the well-known "international style".

The apartment that was built is meant to accommodate two people, in a 50m2 space, with a winter garden. The layout suits the young professionals' lifestyle, who tend to work from home more and more. The space can easily adapt: from a flexible working space, to individual bedrooms at night, thanks to sliding walls and foldable beds.

The living space can also be expanded to the winter garden, which plays a vital role in the apartment's technical performance. It indeed pre-heats and/or pre-cools, but also filters the air. This ensures great indoor comfort conditions and a low energy demand.

The prototype built by the MOR team is currently standing in the Green Village, TU Delft.

See more details about this project

https://issuu.com/okanturkcan/docs/mor_performance_report_final
http://mor.tudelft.nl/

Photo credit

MOR team TU Delft

Stakeholders

Contractor

Name : JP van Eesteren BV
Contact : Hanzeweg 16, 2803 MC Gouda - info[a]jpvaneesteren.nl - tel:0888230100
https://www.jpvaneesteren.nl/nl

Construction Manager

Name : MOR team TU Delft
Contact : Francesco Longo, Delft, the Netherlands. longo.francesco93[a]gmail.com

Stakeholders

Function : Manufacturer

De Groot en Visser

De Groot & Visser BV Marconiweg 1 4207 HH Gorinchem

https://www.degrootenvisser.nl
Manufacturing of the facade modules, and help placing the facade on site

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Function : Facility manager

Croon Wolter en Droos

Marten Meesweg 25 3068 AV Rotterdam

https://www.croonwolterendros.nl/nl
Main installer

Function : Investor

ABN AMRO

https://www.abnamro.nl
Financial supporter

Contracting method

Other methods

If you had to do it again?

In general, the construction process was quite difficult, as we had to do most of it by ourselves, some students having never been on a construction site, actively building things, working with tools, working in height, directing cranes, trucks or automated engines. Managing a construction site is a difficult task in itself, even more tedious when it is about coordinating 40 students, with the pressure of a competition, ensuring safety at all times, and dealing with a construction period limited to 15 days. Being a construction site manager is definitely a job in itself, an we had to learn this on the go. Although we did receive some professional training, and health and safety certification, next time, we will manage a construction site, it will hopefully be with more training, and with professionals. Some of the innovations we integrated didn't perform as we had wished, like the aquaponics system for instance. The system stopped working after some time, as it was not placed under optimal performing conditions. However this innovation was a great research and build experiment, and next time we would place it in a better suited and better controlled environment. However, even though many things did not work out as planned, this was definitely a great learning for all of us, as we all realised that hands-on work is a great eye-opener, and very often much more valuable than theory.

Building users opinion

During the openings and tours we gave of our prototype, both in Delft and in Hungary (where the competition took place), we received great feedback from visitors, especially attracted by the green wall. In general the indoor comfort conditions were great during the competitions week: we managed to keep an average of 23 degrees indoors, under the 40 degrees of the Hungarian summer. Although the prototype has been performing as a pavilion so far, where no one has actually lived in for an extended period of time, the users opinions were great, with people appreciating the quality of the space, the thermal and visual comfort and the acoustics. We are currently setting up a research program, where "digital twins" of buildings will be able to record, measure and track data on performance, user's opinions and experience of the space, in real time.

Energy

Energy consumption

Primary energy need : 51,00 kWhpe/m^2.year

Primary energy need for standard building : 114,00 kWhpe/m^2.year

Calculation method : Other

Breakdown for energy consumption : 51% are appliances and 49% is HVAC

Initial consumption : 114,00 kWhpe/m^2.year

Envelope performance

More information :

Modular aluminium facade with ceramic printed BIPV cladding. Window-to-wall ratio ca. 50%. Windows: Double glazed unit with Ug=0,7

Building Compactness Coefficient : 0,17

Indicator : I4

Air Tightness Value : 0,60

More information

The monitoring of the prototype took place at the site of the Solar Decathlon Europe 2019 (SDE19) competition, in Szentendre Hungary (summer 2019). The SDE19 organization independently tracked the consumption of energy and water. Additionally, comfort conditions were monitored, including temperature, CO2 concentration, humidity levels, daylight conditions and acoustical comfort (noise levels and reverberation). Meanswhile, the occupation of the house was simulated according to a detailed set of rules: The daily house functioning was tested, while providing a realistic scenario for the consumption of resources (hot water draws, running kitchen appliances, washing and drying of clothes, and even hosting dinner parties). A detailed performance report is available online: https://issuu.com/okanturkcan/docs/mor_performance_report_final

Real final energy consumption

Final Energy : 51,00 kWhfe/m^2.year

Real final energy consumption/m2 : 51,00 kWhfe/m^2.year

Real final energy consumption/functional unit : 51,00 kWhfe/m^2.year

Year of the real energy consumption : 2 019

Renewables & systems

Systems

Heating system :

- Individual electric boiler
- Heat pump
- Low temperature floor heating
- Radiant ceiling
- Solar thermal

Hot water system :

- Individual electric boiler
- Heat pump
- Solar Thermal

Cooling system :

- Reversible heat pump

- Floor cooling
- Radiant ceiling
- Others

Ventilation system :

- Natural ventilation
- Nocturnal ventilation
- Double flow heat exchanger

Renewable systems :

- Solar photovoltaic
- Solar Thermal
- Heat pump

Renewable energy production : 137,00 %

Other information on HVAC :

An air-source heat pump (ASHP) is implemented for the prototype. A PCM buffer for the ASHP increases the system's performance. Air source heat pumps have great benefit to their COP when temperature differences are decreased; a 10-20% COP increase can be expected for a 10-degree air temperature reduction. Therefore, we use a PCM battery filled with26 degrees PCM placed in front of the ASHP air intake. The PCM battery will allow for cooler air to pass over the outside unit of the heat pump in summer, while in winter warmer air will prevent the system from entering defrost mode. Charging in summer will be with night air, while in winter the system is linked to our south-facing PVT collector. These collectors will harvest solar energy, which can then beused to recharge the PCM battery. Another innovation in the design of the HVAC system is the use of a low-pressure and low-temperature system. A low-pressure system is used for ventilation. This reduces fan loads, therefore consumption, reduce noise and allows for the system to be later adjusted to increased loads due to climate change or change in use of the building (for example, if it is transformed again in offices).

Direct current (DC) on the residential level is still an emerging technology. Using a DC system in buildings powered by PV energy will result in a controllable, reliable, cheaper system where conversion losses for several appliances are avoided. The use of hybrid AC/DC system is proposed for the MOR renovation of the Marconi Towers and therefore applied in the prototype. The Photovoltaic (PV) system, storage and DC loads are integrated on the DC side of the prototype. The system's alternating current (AC) side consists of the AC loads as well as the central energy management system which also functions as a smart meter, monitoring any power flows to and from the grid.A full performance report is available for this project. It includes the comparison between assumed performance and measured performance of the prototype. (https://issuu.com/okanturkcan/docs/mor_performance_report_final)

Solutions enhancing nature free gains :

Private indoor gardens act as thermal buffer zones. An air inlet leads air through a set of phase change materials. This provides pre-climatized air for the household, with minimal use of energy (by using only a small fan to move the air). The combination

Smart Building

BMS :

The project aims to the development of a "smart passive building" with a central BMS (Building Management System) to control and optimize the operation of the buildingsystems, and therefore to reduce the total energy consumption of the building. Moreover, the application of automation techniques provides the improvement ofuser's domestic comfort, convenience, security and leisure. All the mechanical andelectrical systems will be connected with the main BMS which will control and monitorthe energy consumption at the scale of the building but also on the scale of eachdwelling separately. The interaction of the residents with the home control system and their ability to control security, lighting, ventilation and temperature etc. enhance the potential for managing and reducing the overall energy demand in households and help achieve energy conservation. For the prototype, a design strategy was created so it could control the different systems present. In this case: light system, window and blind control system, HVAC and control of the storage system are all controlled and connected to eachother. All in order to make these systems work together and improve the quality of life of the inhabitants and the energy efficiency of the prototype. The different control schemes of each control are presented now and the overall control strategyand how these controls operate with each other.

Smartgrid :

On the scale of the case study - the Marconi Towers in Rotterdam - the strategy for the electrical grid: The planning stage of power distribution in the Marconi towers involved considerations and measures to cover high levels of safety with integrated installation. Integrated installation involves electrical power distribution; fire suppression systems, heating, air conditioning, ventilation and building control systems. Throughout the design process, it was aimed to achieve:
• Flexibility through entire life cycle of the system• Minimum environmental effect
• High levels of distributed generation and storage
• Cost reduction
Consequently, the electrical system was designed to meet conditions of:
• Simplified operational management by simple, transparent network topology
• Low power loss throughout the distribution• Reliable and safe operational systems
• Sufficient transmission capacity
• Low harmonic distortions in voltage with voltage symmetry, resulting ingood quality of power supply
• Meeting local and international regulations
• Electric vehicles, smart systems
• Low voltage distribution-microgrid topology
Feed-in electrical power distribution system in low voltage level can be classifiedas being a central system or a decentralized system. These are dependenton load requirements as well as spatial conditions. In central distribution, he transformers are concentrated in one place, where the different power distribution circuits share the same bus, whereas in decentralised topology, the transformers are spread over a couple of circuits. Distributed power supply has the advantages of better voltage stability, lower network losses and facilitated easily in compliance with regulations. In a high-rise building like Euro complex Towers with more than 20 floors, it is hence ideal to facilitate remote distribution from an energy centre with low voltage distribution via Alternating Current (AC) and Direct Current (DC) bus bars. The grid connection interface is located at the ground floor and the distributed generation is fed into the LV buses located throughout the towers. Each floor will consistof the normal power supply distribution as well as the SPS and UPS. Lifts and HVAC system will be controlled in a centralised manner. On a prototype scale (as built): Structurally, the prototype is designed to be a cut-out of the Marconi tower albeit a few modifications. On the other hand, the electrical system is designed similarly to a grid-connected system. Meeting the energy requirements of a single module is not as complex as balancing generation and demand for a tower of several hundred modules in a reliable and secure fashion. Rather than scaling down the electrical system of the tower, implementing a

small residential electrical system allows for improvements in cost efficiency while achieving identical results. The main electrical elements of the prototype consists of solar generation, battery storage, electronic converters, electrical loads and a central energy management system. The Photovoltaic (PV) system, storage and DC loads are integrated on the DC side of the prototype. The system's AC side consists of the AC loads as well as the central energy management system which also functions as a smart meter, monitoring any power flows to and from the grid.AC/DC SystemIn evaluating the feasibility of a hybrid AC/DC system for a grid-connected residential building, several barriers need to be addressed. Even though there have been many researches on DC and its appliances on the residential level, it is still an emerging technology. One of the main barriers is the development of standards and regulations for the DC residential system, specifically in determining universal voltage levels for consumption. Electronic devices operate at various voltage levels, and unlike standardized AC electrical sockets, a wall outlet used to charge a phone on direct current may be different than one for your laptop. Considering that the distributed generation sources and storage run inherentlyon DC, a DC system is evaluated for both prototype and tower scales. Furthermore, the efficient LED lighting and peripheral electronics such as laptops and mobile phones can be linked/supplied by low voltage DC system. Using a DC system in the houses will result in a controllable, reliable, cheaper system where conversion losses for several appliances are avoided. Eliminating several inverters in between will lead to fewer materials used within the system.This in turn comes at a higher cost. Indeed, in order to successfully facilitate suchsystem, further evaluation should be made in terms of the regulations, applicability to the system and the types of the loads to be used. On a prototype scale (as built): A hybrid coupled AC/DC system with AC interface and distribution point is facilitated. This AC/DC coupled system has two coupled buses: an AC bus and a DC bus. The AC Bus will be the interface for AC Loads as well as the connection to the grid, 230 V and 50 Hz. The connection between DC Bus and AC Bus is achieved by means of a transformer less inverter. On the DC Bus, PV, BIPV and Battery storage systems are coupled with DC-DC converters at 48VDC, which later can be stepped down or coupled to the DC Loads. The DC Bus is isolated from the AC system and have its own grounding and protected by surge protective devices.

Environment

Urban environment

The Europoint complex is located in the Merwe-Vierhavens (M4H) district of Rotterdam, the Netherlands. This area is undergoing a transition from an outdated port area with a rich maritime and industrial history, to a place where living, working, and innovation come together, fostering a circular manufacturing industry in Rotterdam.

In line with the undergoing redevelopment of the area, our vision is to contribute making the district innovative and energetically efficient.

Located in the north part of the M4H district, our intervention concerns the Marconiplein and its 3 very recognizable Marconi towers. Their landmark status is what we intend to reinforce, as we want the towers to become the symbol of a new sustainable district in Rotterdam.

We propose these 3 towers to become a “Meeting Point” with both outdoor and indoor activities, capable of answering the needs of new residents and the neighbours, promoting an environment and programs for the community. This idea is reflected in the design of the ground floor of the towers, where public programs, landscape and transportation networks meet.

Therefore, on the Marconiplein, we propose public programs based on the shared-economy principles, for a wide range of users. Outdoors, a public plaza with a park, a playground and a market place will welcome the users. On the ground-floor of the towers, we proposed co-working areas, gym facilities, a kindergarten, an open kitchen and restaurant (which use the locally produced food from the roof garden of the towers).

Besides that, we propose to enhance the accessibility of the area, thanks to shared local means of transport, allowing people to travel freely, without the need of private transport. Examples would include shared electrical cars within the neighbourhood, shared e-bikes or autonomous minibuses. Bike storages will also be spread throughout the area, enhancing the use of clean transportation.

Clear and greener pedestrian and bicycle paths will be made of different materials and crossing points will be signaled for safety reasons. Porous paving will be used in order to avoid water runoff and allow for its natural infiltration. Where possible, vegetation will be implemented in order to reduce heat island effect and also to create an enjoyable promenade.

By addressing the current situation and improving it, our project strives for a more sustainable and resilient environment, fostering a positive change for the city and its users.

This results in a globally replicable and adaptable vision which improves the neighbourhood at different levels, by making it more efficient, sustainable, liveable, resilient, and thus future proof.

Land plot area : 38 727,00 m^2

Built-up area : 41,00 %

Green space : 1 584,00

Products

Product

Aquaponics system

Riverfood + MOR

https://www.schoolandcollegelistings.com/NL/Leiden/1094125183942159/Riverfood

https://www.schoolandcollegelistings.com/NL/Leiden/1094125183942159/Riverfood

Product category : Management / Others

An aquaponics system is a system where multiple edible plants, fruits and fish can be grown without soil. Simply said, in this circular system, fish are fed and produce waste which can then be used as nutrition for the plants when converted by nitrifying bacteria. The plants then treat the water and this goes back to the fish. According to the Food and Agriculture Organisation of the United Nations (Food and Agriculture Organisation of the United Nations, 2014), significantly less water is required in an aquaponics system compared to soil based planting systems since the water is used more efficiently. An article that we wrote about the aquaponics system: https://morstudio.nl/urban-food-poduction/

The visitors of the prototype really loved it, they could eat some of the microgreens grown (we also served them in a salad at several diner parties). Kids especially were very intrigued by the fish! Everyone was very eager to get to know about the system. At night, the grow lights would turn the MOR prototype pink, which was also very intriguing for people, who would ask more questions about it.

PCM green wall

Product category : Structural work / Passive system

There is a PCM (Phase Change Material) battery in the inner garden, the ventilation unit can supply air directly or via the PCM battery from the courtyard. This circuit can be realized with motor-operated air valves. With the same valves, a regeneration fan can also circulate air over the PCM battery to store (solar) heat or free cooling from the inner garden. This is most evident in the rate of energy transition, where PCM can exhibit the phenomenon of supercooling within the process of phase changing and therefore instantly reduce the room temperature.

Costs

Construction and exploitation costs

Renewable energy systems cost : 86 500,00 €

Cost of studies : 641 500 €

Total cost of the building : 127 500 €

Subsidies : 1 231 340 €

Additional information on costs :
Facade Area Total: € 11.786,00
Kitchen Area Total: € 7.000,00
Bedroom Area Total: € 3.000,00
Wall Area Total: € 2.000,00
Garden Module: € 6.000,00
Ceiling Module: € 1.180,00
Floor Module: € 650,00

Health and comfort

Water management

Consumption from water network : 23,30 m^3

Consumption of grey water : 3,00 m^3

Water Self Sufficiency Index : 0.11
Water Consumption/m2 : 0.31
Water Consumption/none : 23.3
For the prototype the water consumption was significantly reduced from 118.5 L/day/person to 74.1 L/day/person. This was achieved by implementing water-saving fixtures such as a vacuum toilet which consumes 1 L of water per flush instead of 6 L per flush, and a shower including shower drain which can together save up to 11 L of water per day. Besides the reduction of water consumption, potable water is not used for all purposes - but rather rainwater and treated greywater for example irrigation and for the flushing the toilet.

Indoor Air quality

MOR scored excellently in especially temperature and CO2 levels: CO2 < 800ppm measured at all times in living room and bedroom. A temperature between 23-25° was achieved during the vast majority of time. (Even though nocturnal ventilation was not allowed to be applied due to Solar decathlon 2019 competition requirements)

Comfort

Health & comfort :

In the selection of building materials, special attention was paid to reduce harmful emissions of volatile compounds (VOC). Additionally, humidity levels and CO2 concentration could be monitored and regulated via the BMS system, operating the ventilation system accordingly. The daylighting conditions were carefully designed, respecting reflection and glare of materials, although the final performance results were not measured during the competition. The automated exterior shading system helps reduce overheating in summer, while the indoor shading cloth can be controlled by the user to minimize glare independently. This is especially important, because the residential spaces are multi-use, flexible spaces for living and working.

Calculated indoor CO2 concentration :

< 800ppm

Measured indoor CO2 concentration :

< 800ppm

Calculated thermal comfort : 23-25°

Measured thermal comfort : 23-25°

Acoustic comfort :

The indoor reverberation time was measured to be **T60=0.55** seconds. The acoustical insulation of the facade is equal to **39 dB.**

Daylight factor : The daylight factor was calculated to be 4% of natural light.

Contest

Reasons for participating in the competition(s)

How often does a concept get the chance to prove its viability in practice? Not often, but MOR's prototype has done exactly that: together with our industry partners and professors we have built and tested the MOR prototype three times in two countries.

We are proud to say MOR has passed all tests with flying marks. From the initial construction and testing in The Netherlands, to the heat and tight schedule of the competition in Hungary, and finally back to the definitive opening at The Green Village: our MOR Prototype has proven its value by delivering high performance at low impact consistently. It is therefore no surprise that we broke a world record for podium prizes and got awarded 3x1st place, 4x2nd place and 1x3rd place out of 10 contests.

With this report we share with you the insights and results from our design, construction and testing process, especially with regards to the energy and building physics performance of MOR. The report is available here: https://issuu.com/okanturkcan/docs/mor_performance_report_final

We thank all involved parties for their contribution and trust in us and look forward to developing and testing new technologies at our Prototype.

Building candidate in the category

Energy & Temperate Climates

GREEN SOLUTIONS AWARDS POWERED BY Construction21.org

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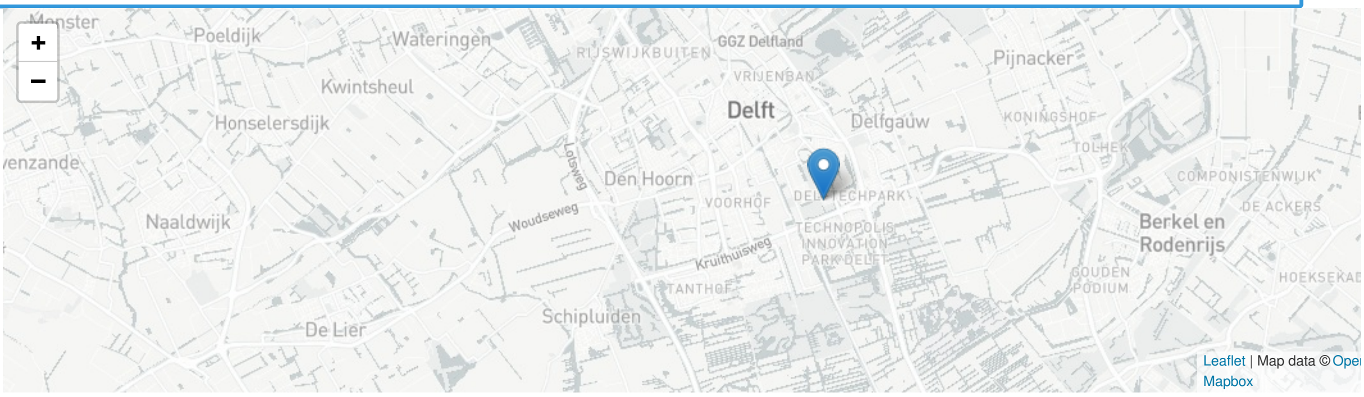


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